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INFLUENCE OF THE ACTIVATORS TO THE DIFFERENT VEGETATION INDEXES IN CENTRAL BOHEMIA REGION

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High proportion of arable land is typically for agriculture in Czech Republic. Nowadays there is a problem with decrease of livestock production and increase of biofuel production. This problems causes decrease in the level of soil carbon in the soil. Decrease in levels of organic carbon also leads to easier soil degradation by other negative factors (soil erosion, compaction). Organic matter application into soils is the only corrective action. Decomposition of applied organic matter is a problem in the decarburized soils. Organic matter can be supplemented by biological transformation's activators. The objective of this paper is to demonstrate the efficacy activators of organic matter to improve the soil environment.
Field trial has been established in this purpose at locality Sloveč in the Central Bohemia Region. Very heavy soil is located on the experimental field. Results of the six variants with application of manure are presented in this paper. PRP Sol (PRP Technologies) was used like soil activator. PRP Fix (PRP Technologies) was used like activator of the biological transformation of manure. Favorable effect on crop state of cereals was observed. This was confirmed by using vegetation indices (using satellite images). They suggest a beneficial effect of application of bio-activators.

Keywords: activator of organic matter, manure application, soil properties, vegetation indices.

INTRODUCTION

Main risks of agricultural land in Czech Republic include water and wind erosion, loss of organic matter in the soil, reducing the biological activity in the soil and soil compaction (Hůla et al., 2010). Degradation of agricultural land usually combines these all phenomena. Recently, there is a turn in this conditions. Organic matter is applied to the soil in many form as manure, compost and waste from biogas plants. Decomposition of organic matter in soils with low levels of carbon may constitute a problem (Ames et al., 1984). This status can be improved by the use of activators of organic matter. The activators can have few forms. Effect of the use of activators on soil properties is relatively new phenomenon. Impact would be expected on the properties of soil (physical and chemical). Another effect would be to improve the state of the crops.

Recently, remote sensing can be very strong tool for crop development monitoring during the vegetation season. Traditional methods for detecting and monitoring essential nutrients in plants needs detailed sampling, time and expensive laboratory chemical analyses; this is neither economically viable nor environmentally acceptable on a large scale (for instance individual farmer's field) (Mahajan et al. 2017). Feng et al. (2008) stated that there are a number of methods proposed for in situ and non-destructive estimation of plant nutritional status like leaf colour chart and chlorophyll meters, but these methods focus on the individual leaves and thus pose difficulty in reflecting a population nutritional status.

The Copernicus programme offers possibilities of Sentinel satellite mission. This missions are essential for the Czech Republic, especially for a member of the European Space Agency. The Sentinel-2 satellites provide high-resolution imagery with revisit frequency of 10 days in case of Sentinel 2A only (https://earth.esa.int). Crop growth and yield can be efficiently monitored using canopy reflectance (Scudiero et al., 2016). Spectral vegetation indices are then the mathematical combinations of different spectral bands that lie mostly in the visible and near infra-red regions of the electromagnetic spectrum (Viña et al. 2011). Vegetation indices can aid in evaluating the spatial variability of crops

through time-series images. Often mentioned vegetation indices in literature are Green Normalised Difference Vegetation Index (GNDVI) (Nigon et al. 2014) and Moisture Stress Index (MSI) (Dupigny-Giroux and Lewis 1999).

The major goal of this study is to discuss the possibilities of time-series Sentinel 2 MSI satellite images and UAV images for the crop growth evaluating with different fertilizer application.

MATERIALS AND METHODS

A field trial has been established in 2014 for the purpose of measuring influence of activators in Sloveč, which is located near the Prague in Central Bohemia Region. . The experiment was based on heavy black soil at an altitude of 214 m, average slope of land 0.3 ° (flat ground). The content of soil particles < 0.01 mm is 38% weight (depth 0-0.3 m). The field experiment consists 6 basic variants. Individual variations represent different dosage of fertilizers and activators. Wheat (*Triticum aestivum L.*) was grown during the season 2016/2017 on all variants. Used fertilizers were: farmyard manure (breeding cattle), and NPK 15-15-15 (Lovofert). Used soil activator in the experiment was PRP Sol (PRP Technologies, France). PRP Sol is composed by a basic matrix of calcium and magnesium carbonate, and mineral elements. Used activator of the biological transformation of manure was PRP Fix (PRP Technologies, France). PRP Fix is a granular mixture of mineral salts and carbonates. Most important thing is that activators cannot be understood as fertilizer. They operate as excipients, and should improve conditions for the transformation of organic matter.

Variants of the experiment:

1. Manure (50 $t.ha^{-1}$)+Fix (200 $kg.ha^{-1}$)+NPK (200 $kg.ha^{-1}$).
2. Manure (50 $t.ha^{-1}$)+Fix (200 $kg.ha^{-1}$)+Sol (200 $kg.ha^{-1}$)+NPK(200 $kg.ha^{-1}$).
3. Manure (50 $t.ha^{-1}$)+ NPK (200 $kg.ha^{-1}$).
4. Manure (50 $t.ha^{-1}$)+ Sol (200 $kg.ha^{-1}$)+NPK(200 $kg.ha^{-1}$).
5. Sol (200 $kg.ha^{-1}$)+NPK(200 $kg.ha^{-1}$).
6. NPK(200 $kg.ha^{-1}$)- control variant.

In April 2016, measurements of soil properties were taken. Data were subsequently analyzed with utilization of software Microsoft Excel (MS Corp., USA) and Statistica 12 (Statsoft Inc., USA).

Sentinel 2A images were obtained from the Amazon Web Services (http://sentinel-pds.s3-website.eu-central-1.amazonaws.com/). All cloud-free images (see Table 2) available over the study area from the years 2016 between April and June have been selected. ENVI 5.4 (Excelis, Inc., McLean, USA) remote sensing software was used for processing all the images. In one case, UAV images were used.

Table 1 Available Sentinel 2A images for the selected year

Crop	Date	Sensor	Satelitte
Wheat	24-Apr-2017, 1-May-2017, 11-May-2017, 14-May-2017, 21-May-2017, 3-June-2017, 10-June-2017, 20-June-2017, 13-July-2017	MSI	Sentinel 2A

The images were downloaded and processed in Level-2A format only. This format is an orthorectified product providing Bottom of Atmosphere (BOA) multispectral reflectance. Selected spectral indices (see Table 3) were calculated.

Table 2 Spectral indices evaluated in this study

Index	Name	Formula	Developed for	Developed by
GNDVI	Green normalised vegetation index	$= (R_{NIR}-R_G)/(R_{NIR}+R_G)$	Chlorophyll	Gitelson et al. (1996)
MSI	Moisture stress index	$= \frac{R_{MidIR}}{R_{NIR}}$	Leaf water content	Rock et al. (1985)

Note: R_G, R_{NIR}, R_{MidIR}, are the reflectances for green, middle IR and NIR bands

RESULTS AND DISCUSSION

Figure 1 and 2 shows a GNDVI index for all variants in 11 terms. During the major growth phases (BBCH 10-59- see Fig. 1), crop stand shows higher values of GNDVI index in variants with manure and activators. The highest values were observed in Variant 2 (both activators with manure). This applies to most monitored terms. During the later stages of vegetation (after BBCH 60), the situation was not clear- see Figure 2. Values alternate for each variation, but the trend remains. This trend indicates better physiological condition of plants of the variants wherein the manure has been applied together with the activators. Differences between of variants are not too large.

Changes in values will also be affected by color change during the flowering phase. The most accurate data is obtained during measurement 19.6. Imaging was performed using a UAV, which has a higher resolution than satellite images. This control measurement confirmed the correctness of the conclusions drawn from the satellite images. After the flowering phase and after it occurs at cereals, physiological changes and vegetation indices may vary considerably due to changes in the color of vegetation and decrease in chlorophyll content. However, the beneficial effect of the application was demonstrated in all cases throughout the reference period. From the values of GNDVI, a beneficial effect of activators linked to an increase in microbial activity in the soil, which leads to better prosperity of plants.

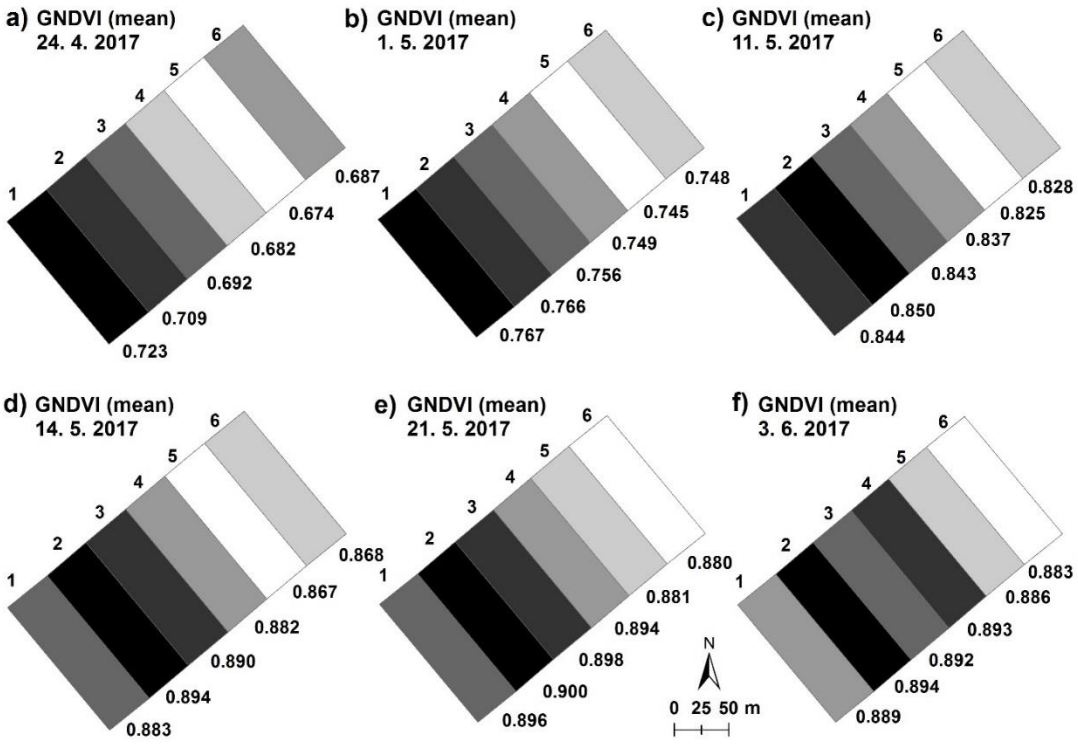

Figure 1. GNDVI index for all variants in Sloveč between 24.4- 3.6.2017

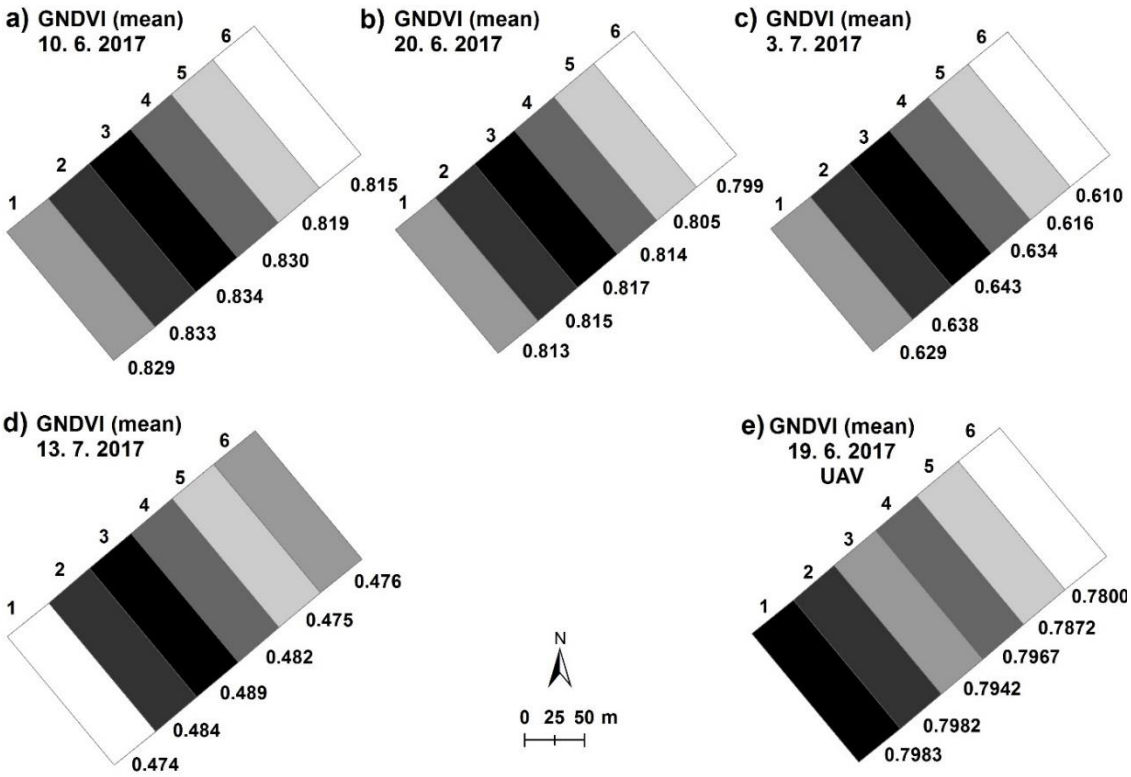

Figure 2. GNDVI index for all variants in Sloveč between 10.6- 19.6.2017

Figure 3 and 4 shows a MSI index for all variants in 10 terms. The lowest value of water stress shows variant 2 in most terms. Generally, plants have not suffered from drought stress during vegetation. MSI index values were generally low. In 8 cases, the positive effect of the application of manure and activators can be discerned. MSI index reflects the degree of stress of plants in terms of their water-supply. MSI index therefore clearly demonstrates the effect of manure application with activators for plant. Only 24.4, the effect was not confirmed. The values in the pheno stage BBCH 30-70 demonstrated a beneficial effect of manure application with activators on water supply of plans. This was probably caused due to a changes of soil properties (increase in soil porosity). Plants are better supplied by ground water during drought time. Absolute differences among variants were majority small. Overall, this phenomenon needs a long-term

research on multiple locations with different soil conditions. From the values of the MSI, a beneficial effect of activators on the decomposition of organic matter in soil may be expected which may result to an improved capillarity of soil water.

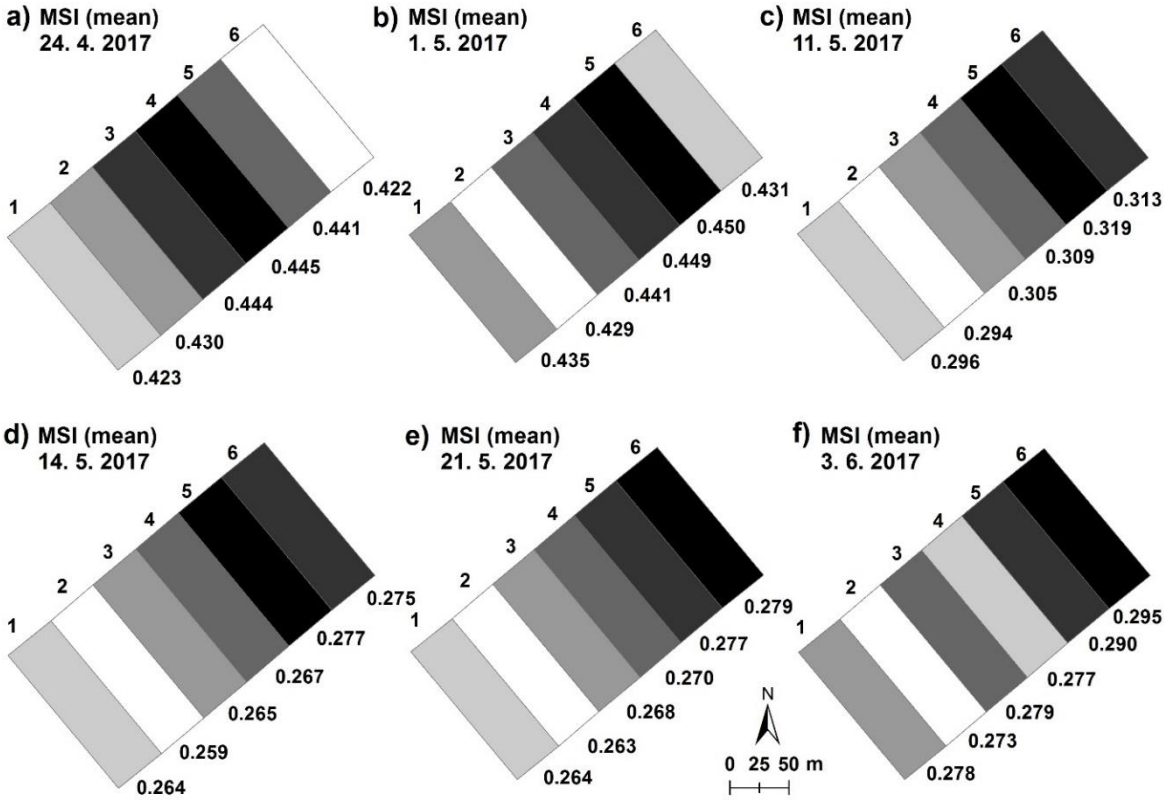

Figure 3. MSI index for all variants in Sloveč between 24.4- 3.6.2017

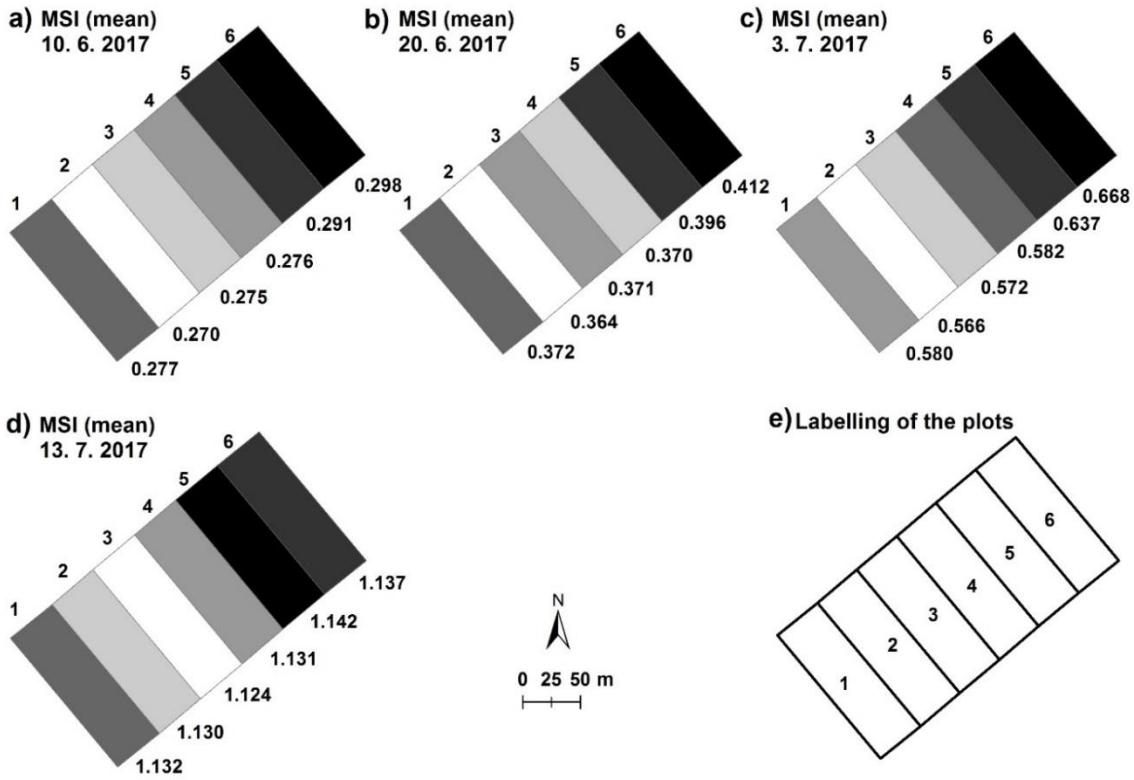

Figure 4. MSI index for all variants in Sloveč between 10.6- 19.6.2017

The correlation coefficients between GNDVI and MSI were calculated for every image and variants (see Table 3). The results are in accordance with the text above. The MSI index is a reflectance measurement that is sensitive to

increasing leaf water content. The MSI index is inverted relative to the GNDVI spectral index. This corresponds to the negative correlation values.

Table 3 Correlation coefficients between GNDVI and MSI from Sentinel 2 satellite images.

	Variant 1	Variant 2	Variant 3	Variant 4	Variant 5	Variant 6
Number of pixels	60	62	61	60	61	61
24.4.2017	-0.813	-0.827	-0.706	-0.576	-0.590	-0.757
1.5.2017	-0.488	-0.173	-0.206	-0.347	-0.236	-0.810
11.5.2017	-0.744	-0.646	-0.578	-0.479	-0.671	-0.677
14.5.2017	-0.792	-0.746	-0.625	-0.555	-0.681	-0.671
21.5.2017	-0.678	-0.646	-0.502	-0.367	-0.675	-0.594
3.6.2017	-0.522	-0.540	-0.586	-0.741	-0.806	-0.552
10.6.2017	-0.661	-0.655	-0.662	-0.665	-0.770	-0.460
20.6.2017	-0.643	-0.686	-0.725	-0.607	-0.758	-0.517
3.7.2017	-0.821	-0.890	-0.752	-0.550	-0.776	-0.586
13.7.2017	-0.570	-0.636	-0.481	0.011	0.016	0.037

Similar studies were often targeted for soil properties. Hůla and Kovaříček (2010) found the beneficial effect of organic matter on soil properties (decrease bulk density and increase porosity). During this study, a positive effect on the management of soil moisture and yield of crops was observed. This was probably caused due to a higher porosity of soil. Higher porosity should also lead to a higher rate of water infiltration into the soil. Application of organic matter together with activators resulted in better supply of plants with water. This is confirmed in study of influence of activators on soil capacity (Šařec and Novák, 2016). This phenomenon corresponds with the MSI index values in this study for mostly dates. Vegetation indices represent a powerful tool for assessing crop condition (Kumhálová et al., 2014). Consistency between vegetation indices and yield can be found (Dominguez et al., 2015). Overall, the application of soil activators and of activators of organic matter constitutes a relatively new problem that merits further research in many aspects.

CONCLUSIONS

Application of organic matter and activators resulted in improvement of properties of soil, this lead to an improvement in water-supply of plants during the period of dryness situations. This is confirmed by MSI index values of individual variants. Application resulted in improvement of the physiological state of plants, which was reflected in an increased GNDVI index. These results of our research are not entirely clear and need long-term verification and with more types of crops with different root systems (rape, corn…..). Our research must be carried out at various locations with different soil conditions and different crops types and rotation.

It will be necessary to see the influence of activators on yield of all crops. The yield results again suggest a beneficial effect of activators of organic matter in order to improve the soil environment- this has not been evaluated in the context of this paper.

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